ST SERVICE RESEARCH NOTE NE-267
1978

Northeastern Forest Experiment Station

FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE, 370 REED ROAD, BROOMALL, PA. 19008

HYBRID POPLAR ON TWO ANTHRACITE COAL-MINE SPOILS: 10-YEAR RESULTS

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Abstract. Unrooted dormant cuttings of 28 hybrid poplar clones were planted on two graded anthracite coal-mine spoils derived from sandstone or from glacial till. Ten-year results show that the plantation survived very well (82 percent), but that growth was extremely varied. Spoil Characteristics and performance of individual clones are presented.

INTRODUCTION

There are about 50,000 ha of mine spoils in the anthracite coal region in northeastern Pennsylvania. Most of the waste area is devoid of vegetative cover, which is essential for stablizing the spoils and minimizing erosion.

Coal operators are now required by law to grade the strippings and revegetate the spoils with trees, shrubs, or grasses when mining is completed. A well-executed afforestation program is an effective way to correct severe environmental problems from strip mining.

Planting fast-growing hybrid poplar (*Populus* spp.) is an effective way to revegetate these harsh sites. It is essential, however, to use planting stock from clones that are best suited to these sites to achieve acceptable survival and growth rates.

In this paper I present 10-year results of the performance of 28 clones of hybrid poplar planted on anthracite coal-mine spoils in northeastern Pennsylvania.

STUDY

In the spring of 1964, 28 clones of hybrid poplar, with 32 cuttings from each clone, were planted in 16 blocks on graded strip-mine spoils. Between 1964 and 1973, 10 blocks were lost due to stripping-related activities, so complete 10-year data could be collected for only six blocks. In

Table 1.—Hybrid poplar clones, their parentages and performance, 10 years after planting

Clone	Parentage (Female X Male)	Sandstone						Glacial till		
		Block A			Block B + C			Block A + B + C		
		Height	Dbh	Trees	Height	Dbh	Trees	Height	Dbh	Trees
		m	*cm*	*No.*	*m*	*cm*	*No.*[a]	*m*	*cm*	*No.*[a]
NE-4	*P. nigra* X *P. laurifolia*	17.5	18.7	2	4.5	2.7	3/1	3.9	2.2	3/2
NE-9	*P. nigra* X *P. trichocarpa*	18.0	19.8	2	5.2	5.8	4	6.3	5.1	4
NE-11	*P. nigra* X *P. trichocarpa*	18.3	22.1	1	6.0	4.6	4	7.4	6.4	5
NE-17	*P.* cv. Charkoviensis X *P.* cv. Caudina	15.9	10.7	1	3.0	1.0	1/1	7.3	5.5	5
NE-29	*P.* cv. Charkoviensis X *P. trichocarpa*	15.9	17.3	1	5.5	4.3	4	6.7	5.3	4/2
NE-32	*P.* cv. Angulata X *P.* cv. Berolinensis	7.3	4.1	1	2.7	1.0	1	3.3	1.8	4/1
NE-35	*P.* cv. Angulata X *P.* cv. Plantierensis	13.9	14.2	2	4.3	3.0	4	6.5	5.2	3/2
NE-40	*P.* cv. Petrovskyana X *P.* cv. Caudina	8.1	5.6	2	2.9	1.4	4	3.6	2.1	5
NE-42	*P. maximowiczii* X *P. trichocarpa*	15.2	14.0	2	10.5	10.9	3	8.8	9.1	5
NE-44	*P. maximowiczii* X *P.* cv. Berolinensis	13.6	11.2	2	9.3	10.3	4	8.0	7.8	6
NE-50	*P. maximowiczii* X *P.* cv. Berolinensis	17.8	17.0	2	6.8	3.8	3	5.0	2.8	4
NE-51	*P. maximowiczii* X *P.* cv. Plantierensis	16.0	15.6	2	6.6	5.9	4	5.3	4.0	6
NE-52	*P. maximowiczii* X *P.* cv. Plantierensis	9.1	6.7	2	7.6	6.7	4	7.0	6.3	6
NE-53	*P. maximowiczii* X *P.* cv. Caudina	14.8	11.8	2	5.4	3.7	4	6.2	3.9	4/1
NE-207	*P. deltoides* X *P. trichocarpa*	14.0	16.8	2	10.4	11.2	4	6.8	6.6	5/1
NE-216	*P. deltoides* X *P. trichocarpa*	12.0	13.8	2	5.7	6.7	2/1	4.0	3.1	5/1
NE-241	*P. deltoides* X *P.* cv. Plantierensis	12.7	13.3	2	4.5	2.3	4	3.0	1.3	2
NE-253	*P.* cv. Angulata X *P. trichocarpa*	14.3	9.9	1	7.2	7.4	4	3.7	2.4	2
NE-258	*P.* cv. Angulata X *P. deltoides*	14.6	11.7	1	5.9	5.2	3/1	5.6	4.8	2/2
NE-273	*P. sargentii* X *P.* cv. Italica[b]	14.4	13.9	2	3.7	1.9	2/1	4.8	2.7	4/1
NE-278	*P. nigra* X *P.* cv. Eugenei	14.9	11.2	1	4.8	3.2	4	9.2	9.0	4
NE-279	*P. nigra* X *P. laurifolia*	14.3	16.5	1	7.9	7.2	4	8.3	8.4	4/2
NE-302	*P.* cv. Betulifolia X *P. trichocarpa*	15.5	14.1	2	7.2	4.8	2/2	3.4	1.5	5
NE-316	*P.* Charkoviensis X *P.* cv. Robusta	14.0	11.4	1	5.8	3.0	1	3.7	2.0	3
NE-327	*P.* cv. Candicans X *P.* cv. Berolinensis	13.4	12.7	2	5.6	4.0	3/1	3.0	1.6	4/1
NE-341	*P.* Rasumowskyana X *P.* cv. Plantierensis	16.5	14.7	1	5.8	3.6	2	7.5	5.8	3
NE-353	*P. deltoides* X *P.* cv. Caudina	15.7	14.1	2	2.9	1.2	3	7.4	5.7	3
NE-388	*P. maximowiczii* X *P. trichocarpa*	17.2	21.1	2	6.2	4.7	2/1	5.4	3.7	6
	Average	14.4	13.9	82%	6.1	5.1	86%	5.9	4.7	79%

[a] Numbers following slash represent trees less than 1.37 m in height.
[b] Trees were removed after 6th growing season. The data is interpreted from 5th year growth.

these blocks, 272 of the 336 trees planted survived (82 percent).

Sites. The study sites were located in the anthracite northern coal field, Luzerne County, Pennsylvania. Sites represented spoils of: (a) sandstone derived from upper carboniferous Pennsylvania age rocks, and (b) glacial till material of Quaternary age. The sandstone spoils contained an admixture of conglomerates and carbonaceous black shale fragments, and both spoil types contained weathered and eroded material. It was estimated that the spoils originated 20 to 25 years earlier, but 2 years before the study began, all areas were graded to slopes of about 10 to 20 percent. There was no vegetation on the sites when the study began.

Hybrid poplar. Dormant cuttings from the 28 hybrid poplar clones used in this study (Table 1) were about 1 to 2 cm in diameter at midpoint and 25 cm long. The cuttings were obtained from the Pennsylvania Department of Forest and Waters, West Virginia Pulp and Paper Company, and research plots of the Northeastern Forest Experiment Station, Beltsville, Maryland.

Plot layout. Plantings were arranged in randomized complete blocks; blocks were replicated three times on each of the two spoil types. Each block consisted of seven rows of cuttings, eight cuttings per row. Two cuttings from each clone were planted adjacent to each other in the same row. Spacing was at 1.8 m.

Data collection and analysis

Spoils. After planting, two 15-kg spoil samples were collected from the upper 30 cm on each block to determine the spoil's physical characteristics. Samples were air-dried and screened, and fragments larger than 5.1 cm in diameter were discarded. The fraction less than 2 mm in diameter was analyzed for sand, silt, and clay-size particles, by the hydrometer method.

In the fall of 1964, triplicate samples were taken to determine field capacity. Sampling was done when the amount of water in the soil approximated the field capacity (1 day after heavy rain). Each site was sampled two or three times. The 15-bar moisture content, determined by the pressure membrane procedure, was considered to equal permanent wilting point.

After five growing seasons, when differences in performance of individual clones on different spoil types and blocks were obvious, additional spoil samples were collected within 4 to 6 cm of each planted cutting to obtain data on chemical characteristics. Samples were analyzed for pH, N, P, exchangeable cations, and exchange acidity.

Trees. Data on survival and on total height of planted trees were obtained annually for 5 years and again after the 10th growing season. The diameter of all trees $\geq$ 1.5 m in height was measured in the 10th season after planting.

Because of large variability of tree growth within spoil types and a possible spoil type x clone interaction, it was not meaningful to rank collectively the performance of individual clones. Therefore results from blocks with similar growth patterns were combined and tabulated.

RESULTS AND DISCUSSION

The number of surviving trees and their height and diameter by clonal original and spoil type are given in Table 1. The performance of individual clones differed greatly among spoil types and blocks within the same spoil type.

Sandstone spoils

Block A. Among three blocks planted, Block A provided exceptionally favorable conditions for tree growth. Here, 82 percent of the planted cuttings survived; the average height was 14.4 m, and the mean diameter at breast height (dbh) was 13.9 cm. The clones NE-4, NE-9, NE-11, NE-50, and NE-388 (Fig. 1) attained a spectacular height of 17 m or higher, and the diameter of these clones ranged from 17 to 22 cm. Conversely, height growths of 10 m and less, and diameters ranging from 4 to 7 cm, were recorded for NE-32, NE-40, and NE-52 clones. The majority of clones (20) in Block A ranged from 10 to 17 m in height, and 10 to 17 cm in dbh.

Blocks B and C. Tree growth on these two blocks was satisfactory but less spectacular than that for Block A. Here, 86 percent of the trees survived, but overall mean height was only 6.1 m and mean dbh was only 5.1 cm. Only two clones, NE-42 and NE-207, exceeded a height of 10 m. Clones NE-44, NE-52, NE-253, NE-279, and NE-302 attained heights ranging from 7 to 10 m and diameters ranging from 5 to 10 cm. The remaining clones grew less than 7 m. Nine trees of 8 clones planted in Blocks B and C didn't reach a height to be measured for dbh.

The reasons for these striking differences in performance between Block A and Blocks B and C

Figure 1.—Fifteen-year-old hybrid poplar (NE-388) on spoil derived from sandstone; the spoil is located near Wilkes Barre, Pa.

cannot be easily explained. It is generally agreed that tree vigor, and particularly tree height at a certain age, is a function of many combined site factors—most frequently those related to the availability of water. Although all three sites had similar physical surface characteristics (Table 2), it is possible that subsurface characteristics in Block A were more favorable for tree growth than those of Blocks B and C.

The chemical characteristics showed small differences among the three blocks (Table 3). Nitrogen concentrations were low but comparable on all three blocks. However pH, P, Ca, Mg and percent base saturation were more favorable on Block A than on Blocks B and C. Perhaps a higher concentration of cations and P affected the more efficient use of N by trees planted on Block A.

Glacial till spoils

With the exception of a few trees that died back due to damage and root exposure from erosion, all clones planted on glacial till spoils survived and grew equally well in all three blocks. Thus growth data from individual blocks were averaged and presented as means of three blocks considered to be replicates.

Seventy-nine percent of the trees survived on glacial till spoil, which I consider good survival. However the plantation attained only 5.9 m in overall mean height and 4.7 cm in dbh. Only nine

Table 2.—Physical characteristics of planting sites.

Spoil	Texture >2.0 mm	Texture Sand	Texture Silt	Texture Clay	Db[b]	Water Retention[a] FC	Water Retention[a] PWP	Water Retention[a] Available water
	%	%	%	%	*g/cc*	%	%	*cm/30.0 cm*
Sandstone	57	28	11	4	1.5	10	2	3.6
Glacial till	43	34	13	10	1.8	8	4	2.2

[a] Determined in >2-mm fraction and adjusted to field conditions.
[b] Disturbed volume weight.

Table 3.—Chemical characteristics of planting sites.

Block	N	P	Ca^{++}	Mg^{++}	K^{+}	Exchange acidity	CEC	Base saturation	pH
	%	*ppm*		- - - - - - -*meq/100g*.- - - - - - -				%	
				SANDSTONE SPOILS					
A	.13	5.2	4.42	2.29	.21	4.05	10.99	63	5.6 (5.2-6.0)
B	.16	2.2	1.78	2.04	.22	5.98	10.04	40	4.9 (4.3-5.4)
C	.12	1.4	1.14	1.08	.22	4.81	7.26	34	4.8 (3.6-5.2)
Mean	.14	2.9	2.45	1.80	.22	4.95	9.43	46	5.1 (4.4-5.5)
				GLACIAL TILL SPOILS					
A	.11	33.1	3.08	1.82	.13	.76	5.81	87	6.8 (6.0-8.4)
B	.09	25.5	2.49	1.60	.12	1.06	5.29	80	6.6 (5.3-7.8)
C	.05	40.1	1.63	1.22	.06	.52	3.45	85	6.8 (5.9-8.0)
Mean	.08	32.9	2.40	1.55	.10	.78	4.85	84	6.7 (5.7-8.1)

clones, NE-11, NE-17, NE-42, NE-44, NE-52, NE-278, NE-279, NE-341, and NE-353, attained a height $\geq$ 7 m; diameter (dbh) ranged from 5.5 to 9.1 cm. Four clones, NE-32, NE-241, NE-302, and NE-327, performed poorly; their height growth was only 3 m. The remaining 15 clones ranged from 3 to 7 m in height and 2.0 to 6.6 cm in dbh, while 16 trees of 11 clones did not reach a height to be measured for dbh.

Although the trees planted on glacial till spoils survived well, their growth rates were below expectations. No one clone performed exceptionally well. The exact reasons are not known, but data on spoil characteristics allow certain assumptions. Favorable pH, percent base saturation, and P concentration are associated with good tree growth (Table 3). But total bases, CEC, and percent N became limiting factors for better performance.

Perhaps the very low amounts of available water during the growing season were major limiting factors to tree growth (Table 2).

CONCLUSIONS

On the basis of the limited results of this study, it is concluded that:

1. Hybrid poplars have good potential in afforestation of anthracite strip-mine spoils.
2. Sandstone-derived spoils provide somewhat more favorable growing sites than spoils derived from glacial till.
3. A number of clones planted on these two spoil types will achieve good survival and a growth range from remarkable to poor, depending on microsite of individual spoil.

MANUSCRIPT RECEIVED FOR PUBLICATION 14 APRIL 1978

☆U.S. GOVERNMENT PRINTING OFFICE: 1978— 703-112:56